

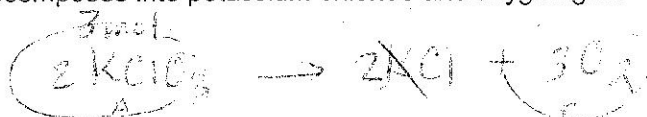
Mixed Stoichiometry Practice

Name _____

Write and/or balance the following equations (remember the diatomic elements and to criss-cross charges for ionic compounds!!!) Use the mole ratios from the balanced equations to solve the following stoichiometry problems. Use units and labels in all conversions, and round your answer to sig figs.

1. Potassium chlorate decomposes into potassium chloride and oxygen gas.

Balanced Equation:

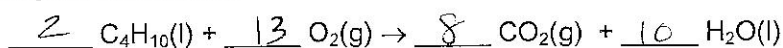


How many moles of oxygen are produced when 3.0 moles of potassium chlorate decompose completely?

$$3.0\text{ mol KClO}_3 \left(\frac{3\text{ mol O}_2}{2\text{ mol KClO}_3} \right) = 4.5\text{ mol O}_2$$

2. Butane (C₄H₁₀) undergoes combustion.

Balanced Equation:

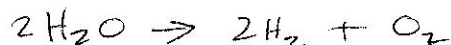


How many grams of CO₂ are produced when 88 g of O₂ are reacted with an excess of butane?

$$88\text{ g O}_2 \left(\frac{1\text{ mol}}{32\text{ g}} \right) \left(\frac{8\text{ mol CO}_2}{13\text{ mol O}_2} \right) \left(\frac{44.02\text{ g}}{1\text{ mol CO}_2} \right) = 6.9\text{ g CO}_2$$

3. Water decomposes into hydrogen gas and oxygen gas by electrolysis.

Balanced Equation:



- a. How many grams of hydrogen will be produced when 6.0 moles of oxygen are produced?

$$6.0\text{ mol O}_2 \left(\frac{2\text{ mol H}_2}{1\text{ mol O}_2} \right) \left(\frac{2\text{ g}}{1\text{ mol}} \right) = 384\text{ g H}_2$$

- b. How many grams of water are required to produce 1.5L of hydrogen at STP?

$$1.5\text{ L} \left(\frac{1\text{ mol H}_2}{22.4\text{ L}} \right) \left(\frac{2\text{ mol H}_2\text{O}}{2\text{ mol H}_2} \right) \left(\frac{18.02\text{ g}}{1\text{ mol H}_2\text{O}} \right) = 1.2\text{ g H}_2\text{O}$$

mass — mole — mole — mass

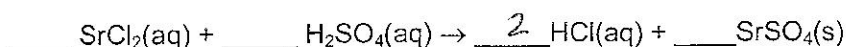
4. Cobalt(II) chloride reacts with fluorine in a single replacement reaction to produce cobalt(II) fluoride and chlorine gas.

Balanced Equation: $\text{CoCl}_2 + \text{F}_2 \rightarrow \text{CoF}_2 + \text{Cl}_2$

How many liters of fluorine are required to produce 290.8 g of cobalt(II) fluoride? Density of Fluorine is 1.7 g/L under the conditions of this experiment.

$$290.8 \text{ g CoF}_2 \left(\frac{1 \text{ mol CoF}_2}{96.93 \text{ g}} \right) \left(\frac{2 \text{ mol F}_2}{1 \text{ mol CoF}_2} \right) \left(\frac{38.00 \text{ g}}{1 \text{ mol F}_2} \right) = 114 \text{ g F}_2$$

5. Balance the following equation.



10 mol 3 mol

What is the mass of strontium chloride that reacts with 300.0 g of sulfuric acid?

$$10 \text{ mol H}_2\text{SO}_4 \left(\frac{1 \text{ L}}{1800 \text{ mol}} \right) \left(\frac{3 \text{ mol SrCl}_2}{1 \text{ mol H}_2\text{SO}_4} \right) \left(\frac{158.52 \text{ g}}{1 \text{ mol SrCl}_2} \right) = 4.7 \rightarrow 5 \text{ g SrCl}_2$$

6. Solid iron(III) oxide reacts with hydrogen gas to form iron and water.

Balanced Equation:



- a. How many grams of iron are produced when 450 grams of iron(III) oxide are reacted?

$$450 \text{ g Fe}_2\text{O}_3 \left(\frac{1 \text{ mol Fe}_2\text{O}_3}{159.7 \text{ g}} \right) \left(\frac{2 \text{ mol Fe}}{1 \text{ mol Fe}_2\text{O}_3} \right) \left(\frac{55.85 \text{ g}}{1 \text{ mol Fe}} \right) = 27.9 \rightarrow 28 \text{ g Fe}$$

- b. How many grams of water will be produced when 3.2 L of hydrogen gas react completely with iron(III) oxide at STP?

$$3.2 \text{ L H}_2 \left(\frac{1 \text{ mol H}_2}{22.4 \text{ L}} \right) \left(\frac{3 \text{ mol H}_2\text{O}}{3 \text{ mol H}_2} \right) \left(\frac{18.02 \text{ g}}{1 \text{ mol H}_2\text{O}} \right) = 2.6 \text{ g H}_2\text{O}$$

3 Ways to solve these problems

LIMITING REAGENT Practice Problems

1. At high temperatures, sulfur combines with iron to form the brown-black iron (II) sulfide:
 $\text{Fe (s)} + \text{S (l)} \rightarrow \text{FeS (s)}$

In one experiment, 7.62 g of Fe are allowed to react with 8.67 g of S.

- a. What is the limiting reagent, and what is the reactant in excess?

#1 Compare mole ratios

$$7.62 \text{ g Fe} \left(\frac{1 \text{ mol Fe}}{55.85 \text{ g}} \right) = 0.136 \text{ mol Fe}$$

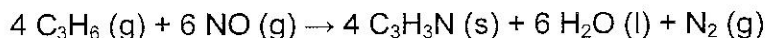
$$8.67 \text{ g S} \left(\frac{1 \text{ mol S}}{32.06 \text{ g}} \right) = 0.269 \text{ mol S}$$

$\frac{0.136 \text{ mol Fe}}{1 \text{ mol S}}$ have $\frac{0.136 \text{ mol Fe}}{0.269 \text{ mol S}}$
 Fe is limiting

- b. Calculate the mass of FeS formed.

$$7.62 \text{ g Fe} \left(\frac{1 \text{ mol Fe}}{55.85 \text{ g}} \right) \left(\frac{1 \text{ mol FeS}}{1 \text{ mol Fe}} \right) \left(\frac{87.92 \text{ g}}{1 \text{ mol FeS}} \right) = 12.0 \text{ g FeS}$$

2. Acrylonitrile, $\text{C}_3\text{H}_3\text{N}$, is the starting material for the production of a kind of synthetic fiber (acrylics) and can be made from propylene, C_3H_6 , by reaction with nitric oxide, NO, as follows:



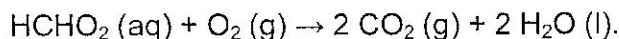
What mass of $\text{C}_3\text{H}_3\text{N}$ can be made when 21.6 g of C_3H_6 react with 21.6 g of nitric oxide?

#2 determine exact amount of reactants needed

$$21.6 \text{ g C}_3\text{H}_6 \left(\frac{1 \text{ mol C}_3\text{H}_6}{42.06 \text{ g}} \right) \left(\frac{6 \text{ mol NO}}{4 \text{ mol C}_3\text{H}_6} \right) \left(\frac{28.01 \text{ g}}{1 \text{ mol NO}} \right) = 20.6 \text{ g NO}$$

20.6 g NO needed but you are given 21.6 g
 NO is in excess
 C_3H_6 is limiting

3. Formic acid, HCHO_2 , burns in oxygen to form carbon dioxide and water as follows:



If a 3.15-g sample of formic acid was burned in 2.0 L of oxygen, what volume of carbon dioxide would be produced? (Assume the reaction occurs at standard temperature and pressure, STP.)

#3 determine product for each reactant limiting reagent least amount of product formed

$$3.15 \text{ g HCHO}_2 \left(\frac{1 \text{ mol}}{46.03 \text{ g}} \right) \left(\frac{2 \text{ mol CO}_2}{1 \text{ mol HCHO}_2} \right) \left(\frac{22.4 \text{ L}}{1 \text{ mol CO}_2} \right) = 3 \text{ L CO}_2$$

$$2.0 \text{ L O}_2 \left(\frac{1 \text{ mol}}{22.4 \text{ L}} \right) \left(\frac{2 \text{ mol CO}_2}{1 \text{ mol O}_2} \right) \left(\frac{22.4 \text{ L}}{1 \text{ mol CO}_2} \right) = 4 \text{ L CO}_2$$

4. Zinc metal reacts with hydrochloric acid to produce zinc chloride and hydrogen gas.

a. Balance the following reaction: $\underline{\quad} \text{Zn (s)} + \underline{2} \text{HCl (aq)} \rightarrow \underline{\quad} \text{ZnCl}_2 \text{ (aq)} + \underline{\quad} \text{H}_2 \text{ (g)}$

b. A 3.50-g sample of zinc metal is allowed to react with 2.50 g of hydrochloric acid.

3.50g Zn (1 mol Zn)

Complete the following table:

Reactants/products	Zn (grams)	HCl (grams)	ZnCl ₂ (grams)	H ₂ (L)
Before reaction	3.50g	2.50g	4.14 0	0.14 0
After reaction	1.26 g	0	4.67	0.768

Zn is excess reactant

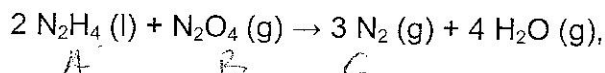
5. Consider the reaction: $\text{MnO}_2 + 4 \text{HCl} \rightarrow \text{MnCl}_2 + \text{Cl}_2 + 2 \text{H}_2\text{O}$

If 0.45 mols of MnO₂ can react with 48.2 g of HCl, how many grams of Cl₂ could be produced?

$$0.45 \text{ mol MnO}_2 \left(\frac{4 \text{ mol HCl}}{1 \text{ mol MnO}_2} \right) \left(\frac{36.46}{1 \text{ mol HCl}} \right) = 65.628 \text{ g HCl (limiting)}$$

$$48.2 \text{ g HCl} \left(\frac{1 \text{ mol HCl}}{36.46 \text{ g}} \right) \left(\frac{1 \text{ mol Cl}_2}{4 \text{ mol HCl}} \right) \left(\frac{70.9}{1 \text{ mol Cl}_2} \right) = 23.4 \text{ g Cl}_2$$

6. One of the components of the fuel mixture on the Apollo lunar module involved a reaction with hydrazine, N₂H₄, and dinitrogen tetroxide, N₂O₄. If the balanced equation for this reaction is



What volume of N₂ gas (measured at STP) would result from the reaction of 1500 kg of hydrazine and 1000 kg of N₂O₄?

$$1.5 \times 10^6 \text{ g N}_2\text{H}_4 \left(\frac{1 \text{ mol A}}{32.04 \text{ g}} \right) \left(\frac{3 \text{ mol N}_2}{2 \text{ mol A}} \right) \left(\frac{22.4 \text{ L}}{1 \text{ mol}} \right) = 1.6 \times 10^6 \text{ L}$$

$$1 \times 10^6 \text{ g N}_2\text{O}_4 \left(\frac{1 \text{ mol B}}{92.09 \text{ g}} \right) \left(\frac{3 \text{ mol C}}{1 \text{ mol B}} \right) \left(\frac{22.4 \text{ L}}{1 \text{ mol}} \right) = 7 \times 10^5 \text{ L N}_2$$

N₂O₄ limiting

7. Chlorine gas reacts with silica, SiO₂, and carbon to give silicon tetrachloride and carbon monoxide.

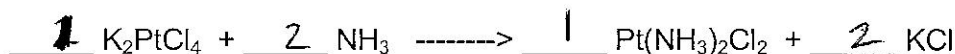
a. Balance the following equation: $\underline{2} \text{Cl}_2 \text{ (g)} + \underline{\quad} \text{SiO}_2 \text{ (s)} + \underline{2} \text{C (s)} \rightarrow \underline{\quad} \text{SiCl}_4 \text{ (l)} + \underline{2} \text{CO (g)}$

b. How much CO gas can be produced from 15.0 g of silica? *AT STP*

$$15.0 \text{ g SiO}_2 \left(\frac{1 \text{ mol SiO}_2}{60.09 \text{ g}} \right) \left(\frac{2 \text{ mol CO}}{1 \text{ mol SiO}_2} \right) \left(\frac{22.4 \text{ L}}{1 \text{ mol CO}} \right) = 11.0 \text{ L CO}$$

Theoretical and Percent Yield Worksheet

1. Given the following equation:



- a) Balance the equation.
b) Determine the theoretical yield of KCl if you start with 34.5 grams of NH_3 .

$$34.5 \text{ g NH}_3 \left(\frac{1 \text{ mol NH}_3}{17.06 \text{ g}} \right) \left(\frac{2 \text{ mol KCl}}{1 \text{ mol NH}_3} \right) \left(\frac{74.55 \text{ g}}{1 \text{ mol KCl}} \right) = 151 \text{ g KCl}$$

- c) Starting with 34.5 g of NH_3 , and you isolate 76.4 g of $\text{Pt}(\text{NH}_3)_2\text{Cl}_2$, what is the percent yield?

$$34.5 \text{ g NH}_3 \left(\frac{1 \text{ mol NH}_3}{17.06 \text{ g}} \right) \left(\frac{1 \text{ mol Pt}(\text{NH}_3)_2\text{Cl}_2}{2 \text{ mol NH}_3} \right) \left(\frac{300.06 \text{ g}}{1 \text{ mol Pt}(\text{NH}_3)_2\text{Cl}_2} \right) = 304$$

$$\frac{76.4}{304} \times 100 =$$

25.1%

2. Given the following equation:



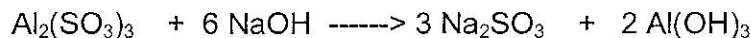
- a) If 49.0 g of H_3PO_4 is reacted with excess KOH, determine the percent yield of K_3PO_4 if you isolate 49.0 g of K_3PO_4 .

$$49.0 \text{ g H}_3\text{PO}_4 \left(\frac{1 \text{ mol H}_3\text{PO}_4}{98.00 \text{ g}} \right) \left(\frac{1 \text{ mol K}_3\text{PO}_4}{1 \text{ mol H}_3\text{PO}_4} \right) \left(\frac{212.27 \text{ g}}{1 \text{ mol K}_3\text{PO}_4} \right) = 106 \text{ g}$$

$$\frac{49.0}{106} \times 100 =$$

46.2%

3. Given the following equation:



- a) If you start with 389.4 g of $\text{Al}_2(\text{SO}_3)_3$ and you isolate 212.4 g of Na_2SO_3 , what is your percent yield for this reaction?

$$389.4 \text{ g A} \left(\frac{1 \text{ mol A}}{294.14} \right) \left(\frac{3 \text{ mol B}}{1 \text{ mol A}} \right) \left(\frac{126.04}{1 \text{ mol B}} \right) = 500.6$$

$$\frac{212.4}{500.6} \times 100 =$$

42.43%

4. Given the following equation:



- a) If you start with 50.3 g of $\text{Al}(\text{OH})_3$ and you isolate 39.5 g of AlCl_3 , what is the percent yield?

$$50.3 \text{ g A} \left(\frac{1 \text{ mol A}}{78.01 \text{ g}} \right) \left(\frac{1 \text{ mol B}}{1 \text{ mol A}} \right) \left(\frac{133.33}{1 \text{ mol B}} \right) = 85.86 \text{ g}$$

5. Given the following equation:

$$\frac{39.5}{85.86} \times 100 = 45.9\%$$



a) Balance the equation.

b) Determine the theoretical yield of KCl if you start with 34.5 g of K_2CO_3 .

$$34.5\text{g} \left(\frac{1\text{mol A}}{138.21} \right) \left(\frac{2\text{mol B}}{1\text{mol A}} \right) \left(\frac{74.55}{1\text{mol B}} \right) = 37.2\text{g KCl}$$

c) Starting with 34.5 g of K_2CO_3 , and you isolate 3.4 g of H_2O , what is the percent yield?

6. Given the following equation: $34.5\text{g} \left(\frac{1\text{mol A}}{138.21} \right) \left(\frac{1\text{mol C}}{1\text{mol A}} \right) \left(\frac{18.02\text{g}}{1\text{mol C}} \right) = 4.50\text{g}$



a) If 98.0 g of H_2SO_4 is reacted with excess $\text{Ba}(\text{OH})_2$, determine the percent yield of BaSO_4 if you isolate 213.7 g of BaSO_4 .

$$98.0\text{g} \left(\frac{1\text{mol A}}{98.08\text{g}} \right) \left(\frac{1\text{mol B}}{1\text{mol A}} \right) \left(\frac{233.3\text{g}}{1\text{mol B}} \right) = 233$$

$$\frac{213.7}{233} \times 100 = 91.7\%$$

7. Given the following equation:



a) If you start with 82.4 g of CaCl_2 and you isolate 82.4 g of $\text{Ca}_3(\text{PO}_4)_2$, what is your percent yield for this reaction?

$$82.4\text{g CaCl}_2 \left(\frac{1\text{mol}}{110.98\text{g}} \right) \left(\frac{1\text{mol B}}{3\text{mol A}} \right) \left(\frac{310.18\text{g}}{1\text{mol B}} \right) = 76.8\text{g Ca}_3(\text{PO}_4)_2$$

8. Given the following equation:

$$\frac{82.4}{76.8} \times 100 = 107\%$$



a) If you start with 50.3 g of $\text{Cr}(\text{OH})_3$ and you isolate 39.5 g of CrI_3 , what is the percent yield?

$$50.3\text{g} \left(\frac{1\text{mol}}{103.03\text{g}} \right) \left(\frac{1\text{mol B}}{1\text{mol A}} \right) \left(\frac{432.7}{1\text{mol B}} \right) = 211\text{g}$$

$$\frac{39.5\text{g}}{211} \times 100 = 18.7\%$$